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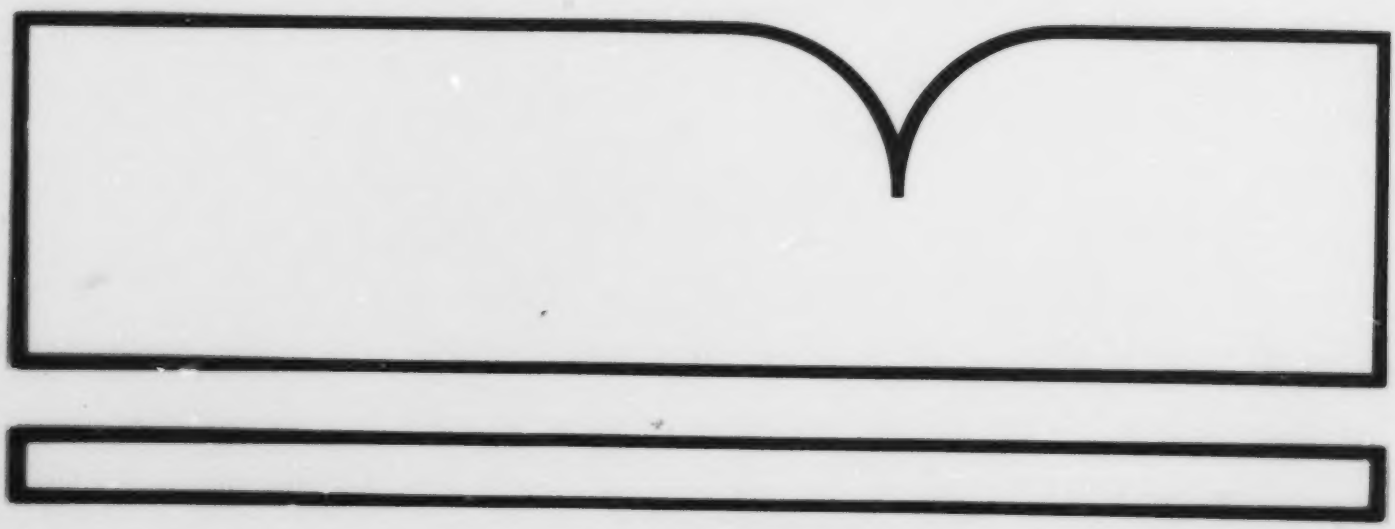

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ONSITE WASTEWATER SYSTEMS POLICY AND REGULATIONS IN THE USA

by

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16. ABSTRACT

The relationship between the Federal, state and local governments with regard to the design and use of onsite wastewater systems are discussed. State codes which generally govern the design and use of onsite systems are subsequently analyzed as to their meaning and variability.

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ONSITE WASTEWATER SYSTEMS POLICY AND REGULATIONS IN THE USA

by James F. Kreissl, Environmental Engineer

1 NATIONAL RELATIONSHIPS

Onsite wastewater treatment and disposal systems have historically been the responsibility of state and local government in the United States. Water Pollution Control Acts prior to the Clean Water Act of 1977 had initiated the Construction Grants Program whereby the Federal government provided a large portion of the cost of construction of wastewater collection and treatment works. During the 1970's the water pollution control program in the U.S. found itself in transition. The major emphasis of program had been based on large urban and suburban complexes where the greatest impact on pollution was attainable with the funds provided by Congress. As these larger population centers had received their Federal assistance and commenced construction, the program shifted to smaller cities which had patiently awaited their turn on state priority lists. In these communities the urban technologies of conventional gravity sewers and complex treatment facilities were suddenly found to represent an often unreasonable cost when apportioned to the system users, even with Federal costsharing. The U.S. Environmental Protection Agency (EPA) required that alternative technologies be evaluated, but found it could not provide grants for individual home systems if that alternative were found most cost-effective, under the 1972 Clean Water Act.

Therefore, the Congress enacted the Clean Water Act of 1977 (P.L. 95-217) which stated its intent to "...redirect the (Construction Grants) program away from the conventional collection and secondary treatment approach and toward the use of alternative technologies...(1)" This Act specifically provided for the eligibility of onsite systems for Construction Grant funding under section 201(h) when a grant-eligible authority applies for the grant and guarantees proper management of these facilities. In fact onsite systems were designated as alternative technology for increased funding (85% instead of the present 75% Federal share for conventional technologies) under the Innovative/Alternative (I/A) provisions of the Act in communities with populations of less than 3,500 or in sparsely populated areas of larger communities.

U.S. EPA regulations require that Federally funded treatment works be designed by an engineer registered in the state in which the project is located and be designed in accordance with that state's design criteria. Although the EPA has developed considerable data on the design of onsite systems through its Office of Research and Development over the past decade, the actual design standards are determined by the state in which the project is located. Most states have codified the design of traditional onsite systems, i.e., septic tank-soil absorption systems (ST-SAS's), and the variation in those codes will constitute the bulk of the following discussion. However, few states have expanded their onsite system regulations to include more recently developed onsite systems which are designed to overcome various site limitations which would otherwise preclude conventional onsite systems.

When other than traditional onsite systems are proposed, state and Federal reviewers have few choices for reference material on which to base their technical reviews. The most complete document is the USEPA Design Manual for Onsite Wastewater Treatment and Disposal (1980) of which over 30,000 copies have already been distributed. Another source of design information for alternative onsite systems is the Recommended Standards for Individual Systems from the Great Lakes - Upper Mississippi River Board of State Sanitary Engineers (1980), i.e., 10 State Standards. Typical of the onsite technology area, these two references differ considerably in their recommended design approaches. A few states have expanded their onsite codes to include certain alternative technologies which have been shown to be effective for commonly occurring site cosntraints within that state. Among these are the States of Maine, Oregon, North Carolina, Wisconsin and Minnesota.

Certain Federal Agencies such as the Department of Housing and Urban Development, Agriculture (Farmers Home Administration), and the Veterans Administration do have traditional onsite system standards. Their regulations are mandatory, unless the state regulations are more stringent. As noted above, the USEPA permits the use of state regulations for Construction Grant-supported projects as long as the grant-eligible agency guarantees proper management, including operation, maintenance and monitoring services.

2 STATE CODES

Plews (1976) has presented a historical picture of state and local onsite system code development, describing their disease prevention origins and their evolution into land use controls, growth stimulation or limitation mechanisms, and other political goals.

To properly accomplish any of these goals a thorough evaluation of the proposed site is required to determine optimum landscape location, soil texture, and structure, with depth, groundwater and bedrock data, hydraulic conductivity data, and information on the volume and character of the wastewater to be absorbed by the soil. The ability to obtain the above data is limited in most areas of the U.S. However, some states and localities have made great advances in upgrading site evaluation through requirements that more highly qualified personnel perform these analyses. In these instances the associated codes are less stringent, giving qualified people an opportunity to consider a variety of designs which may be optimal to each site. In the majority of states, however, less qualified personnel are employed to determine site suitability. Therefore, codes in these states are generally quite rigid, permitting minimal adjustments of designs to site-specific conditions. In many of these same jurisdictions, when a site is declared unsuitable by those personnel, professional engineers are permitted to propose designs which can overcome site limitations. Unfortunately, relatively few engineers have the background to ably provide this type of advanced design.

Since all codes are based on the premise of protecting public health, and since presently employed techniques of onsite pretreatment for soil disposal are not capable of ensuring complete pathogen removal, the health protection factor centers on the proper siting, design, and construction of the soil absorption system (Kreissl, in press). The two primary routes of human disease transmission are: 1) passage of pathogens or chemical contaminants from the disposal trench downward to the groundwater, travelling therein to a point of extraction in sufficient quantity to cause disease and 2) surfacing of unpurified wastewater where direct human contact or overland runoff to improperly cased wells can occur. In order to avoid the latter, the system must be properly sited, designed and constructed to accept the entire volume of wastewater for a long period of time. To avoid the former, the system must be properly designed to avoid localized overloading and to provide sufficient contact time in the unsaturated soil zone to ensure purification.

2.1 HISTORY

Shortly after World War II the Federal Housing and Home Finance Agency and the U.S. Public Health Service initiated a comprehensive study of septic tank-soil absorption system (ST-SAS) technology which included a review of state regulatory codes. This review was published in 1949 (Weibel, 1949). This study had historical significance in that it was the first comprehensive review of state codes regulating onsite wastewater systems. The study revealed a wide variety of codified regulations which had developed from varying local experiences. Interestingly, these regulations were extensive with regard to specifications for septic tanks and less specific and more varied with regard to soil absorption systems.

As a result of the publications from the Public Health Service study (Weibel, 1949) (Bendixen, 1950) (Weibel, 1954) and other studies precipitated by the unsewered housing boom after World War II, the Manual of Septic-Tank Practice (MSTP) (USPHS, 1957) was published in 1957. The impact of this document was so significant that a 1971 review (Patterson, 1971) of state codes revealed an easily perceptable uniformity with the MSTP.

In 1976, however, another review of state codes revealed that a significant level of code revision was occurring which was resulting in a divergence of codes from the MSTP. The causes of these code changes were probably manifold, but were based primarily on local experiences, new research information and the need to accommodate housing in areas unsuitable for conventional ST-SAS designs.

The following discussion is based on the code changes as chronicled in the 1949, 1971 and 1976 surveys and in an unofficial survey conducted by an individual state in 1980 (Virginia, unpublished). The focus of the discussion is on the trends observed over the past three decades and on the physical meaning of the codified parameters.

2.2 SITE EVALUATION

The percolation test has been used for over 50 years as an empiricial measure of the suitability of soil septic tank effluent absorption. Initially, it was devised by Henry Ryon as a measure to be applied to surfacing SAS's and cesspools to determine the maximum allowable loading rates for New York soils. After the tests were run, the lowest loading rate found for failing systems essentially defined the highest loading rate for future designs in soils with that percolation rate.

In the USPHS study (Bendixen, 1950) a similar analysis was performed which showed similar results, i.e., that for soils with percolation rates between 240 and 1440 sec/cm (10 and 60 minutes/inch), allowable loadings should be about 2 percent of the percolation rate.

As the above studies were reported and incorporated into the MSTP and numerous state codes, there was little concern expressed for the fact that the percolation test had no physical meaning and bore no specific relationship to equilibruim conditions in adsorption systems. It was not until the relatively recent work of Bouma (1971) (1977) that these shortcomings were scientifically demonstrated.

It was noted in 1949 (Weibel, 1949) that fourteen states utilized the percolation test for site evaluation and design. After the advent of the MSTP, the 1971 survey (Patterson, 1971) revealed that twenty-six states required percolation testing for system design. By 1976, thirty-six of thirty-nine reporting states used the percolation test, but only 19 used the test results alone for system sizing (Plews, 1976). In 1980, thirty-two states specified its use in design (Virginia, unpublished). Of these, only 7 used the percolation test exclusively (Ward, 1981).

In analyzing the above trends, the percolation test appears to remain extremely popular, despite its proven shortcomings. Since the test appears to be straightforward, semi-skilled technicians appear able to perform it with some reasonable level of proficiency. Despite the fact that tests have been developed which actually measure hydraulic conductivity of the soil under a variety of moisture conditions, the percolation test remains in general use because of the complexity of these other tests. Therefore, the attitude of several code-writers has been to either continue using the percolation test only as one of several data inputs to system design, or to eliminate it altogether and rely on other site evaluation data. The other data in both of the above cases include detailed soil analysis of texture, depth and structure, landscape location and drainage, and prior experience with the identified soil for onsite wastewater disposal. Fortunately the "blind" use of percolation tests for sizing of soil abosrption systems does appear to be waning.

2.3 PRETREATMENT

In 1949, the minimum volume for a septic tank was specified as 1.9 cu m (500 gal) by 21 of 47 states, while in 1980, 28 of 49 states required a minimum of 2.8 cu m (750 gal), and fourteen required 3.8 cu m (1000 gal) or more. With relation to other tank specifications, the 1949 survey noted that 40 states specified a minimum length to width ratio, and 72 percent of those required that ratio between 2 and 3. In 1971, only 8 states specified a minimum length to width, and all but one required it to be 2 to 3. Similarly, of the 41 states requiring a minimum depth in 1949, 89 percent required 1.2 m (4 ft) or more. In 1971 only 22 states had a minimum depth requirement, and over half of those required a minimum depth of 0.9 to 1.2 m (3 to 4 ft). Because of its more comprehensive nature, the 1949 survey contained information on many more details of tank requirements than the subsequent surveys. It noted, for example, that six states recommended two-compartment tanks, while the author is only aware of two states doing so at present. Also, in 1949 four states recommended against inlet baffling or submergence, a nearly universal requirement today.

What do the above trends seem to indicate? Clearly, the code-makers feel that larger tanks are advantageous. However, they are becoming less restrictive on the shape of the tank. Given the reduced septic tank pumping frequency requirement of the larger tank and the concerns for both increased wastewater flow due to modern plumbing fixtures and widespread use of garbage grinders, this progression would appear to be logical. However, earlier intent to improve tank performance through better internal design has apparently given way to perceived benefits of larger tanks.

In only four states included in the 1980 survey are reductions in infiltration area permitted where aerobic treatment units are employed in place of septic tanks. The maximum reduction is 33 percent in the usual range of acceptable percolation rates. In one state the allowable percolation rate is extended from 1440 to 2880 s/cm (60 to 120 min/in) for aerobic pretreatment. No scientific evidence supports any reductions in less permeable soils, although some evidence does exist to support size reduction in sandy soils.

2.4 SOIL ABOSRPTION SYSTEMS

Since the 1949 survey and publication of the Manual of Septic Tank Practice (MSTP), the emphasis of codes has shifted from the pretreatment, e.g., septic tank, to the soil absorption

systems (SAS). This trend has been quite logical given that an SAS is the normal site of failure and failures are not necessarily related to pretreatment. Therefore, the SAS specifications of state codes have been the primary area of revision where excessive failures have occurred in systems which ostensibly have met code requirements.
In 1949 the modal minimum trench width for 27 states was 450 cm (18 in.), while in 1980 it was 30 cm (12 in.). However, of 22 states included in both surveys, 16 changed their requirements over that period, but 10 of those increased the minimum width, and only 6 decreased it. Since the average reported minimums for both surveys are about 45 cm (18 in.), these dimensional requirements offer little insight as to any changing trends with regard to bottom vs. sidewall infiltration.

The 1949 survey did not note any minimum trench depth requirements, but the 1971 survey noted that 17 states did require it. Of the seventeen, 12 required a 60 cm (24 in.) minimum, while all but one of the rest required a lesser minimum depth. In 1980, twice as many states required a minimum depth, with a modal requirement of the same 60 cm (24 in.). Only 5 states required a greater minimum depth. Although modes and averages and the number and direction of changes were minor in this period, the potential danger of the significant increase in the number of states requiring a minimum depth is that it restricts the use of potentially valuable shallow trenches where local conditions are favorable to their use. Likewise, the 1980 survey indicated that 28 states have a maximum depth requirement, which could potentially stifle use of deep trenches in areas where their use might be advantageous.

One very drastic change in trench requirements is in the minimum cover required over the trench. In 1949 half of the codes surveyed cited a "preferred" cover of 45 cm (18 in.), while in 1980 more than half of the states required only 15 cm (6 in.). Clearly, the oft-stated concern for freezing and mechanical damage had diminished, and possibly, some attempt to more effectively use evapotranspiration assistance in disposal may be apparent. The spacing between trenches has been specified by most states for several decades. According to Machmeier (1975) the basis of this requirement relates to the design of construction equipment to permit easy access and avoid disturbing infiltrative surfaces. Unless the space between the trenches is designated by a SAS replacement area, required by 21 of 45 states in 1980, equipment requirements would not require a spacing of more than 1.4 m (4.5 ft.). The

hydraulics of flow from trench sidewalls in non-sandy soils has not been applied to spacing requirements, but it would be expected to vary significantly.

In the 1949 surveys the average minimum trench spacing requirement of 33 states was 2.1 m (7 ft.), while in the 1980 survey 44 states had an average minimum of 1.8 m (6 ft.). Of 28 states included in both surveys, 15 reduced these minimums while only 4 increased them. All of the latter four states had originally required spacing of 1.2 m (4 ft.) or less. It would appear that the trend has been toward reduced spacing sufficient to accommodate construction equipment, which also maximizes the number of trenches and wastewater absorption per unit area of land.

Of course the ultimate practical objective of the SAS is to dispose of wastewater in a manner which results in neither surfacing of the wastewater nor groundwater pollution. To prevent the former the system must provide sufficient infiltrative surface to accept all the wastewater received from the home. Therefore, an analysis of design loading requirements is necessary.

In those states which had already encoded the percolation test in 1949, absorption area requirements had doubled by 1971 for sand soils along with significant, but smaller, percentage increases for finer-grained soils with marginally acceptable percolation times. With regard to very permeable soils, the 1976 survey showed nine states with minimum SAS sizes. The 1980 survey indicated that this number had grown to 29 states, but that the minimum sizes varied widely, from 6.5 m^2 (70 sq. ft.) to 46.5 m^2 (500 sq. ft.) with a mean minimum size of 16 m^2 (175 sq. ft.).

The obvious conclusion is that the required sizing of conventional soil absorption fields has generally increased between 1949 and 1980. The reason for these increases are probably due to unsatisfactory performance of earlier, smaller systems. Given the apparent lack of understanding of the design and functioning of the SAS and its uncertain relationship to the percolation test, the logical choice was to increase the required absorption area. Numerous studies have shown that equilibrium rates of infiltration do occur with time. It is logical that larger systems permit longer system service life. Such reasoning, however, neglects several important factors. The primary one is economics, which includes not only the

extra cost of construction of a larger SAS, but also, when combined with required setback or separation distances, the cost of larger more expensive parcels of property to permit construction of these systems.

2.5 GROUNDWATER CONTAMINATION

The two aspects of codes which deal with groundwater contamination are the vertical separation distance to groundwater and the horizontal separation or setback requirements to household potable water supplies. The vertical separation requirements nominally provide unsaturated soil "contact time" to accomplish treatment of the wastewater before it enters the groundwater.

The 1949 survey showed 34 states with vertical separation requirements varying from 0 to 1.2 m (0 to 4 ft.), with a mode of 1.2 m (4 ft.). In 1980, 41 states required the same range and mode, however, the average vertical separation requirement had risen from 0.8 to 0.9 m (2.6 to 3.0 ft.). Of 20 directly comparable states, 14 had not changed their requirements, 4 increased them, and two had decreased them. Since the contact time between the wastewater and unsaturated soil is the most effective and often the only barrier against groundwater contamination, design requirements must insure that no short-circuiting can occur which would allow insufficient treatment. Bouma (1977) has described the contact time concept in detail. By integration of the Darcy equation he showed a mathematical requirement to provide a minimum of 0.9 m (3 ft.) of unsaturated soil between the trench bottom and the top of the saturated layer to maintain hydraulic acceptance rates at design equilibrium conditions. Contact times for sandy (unsaturated) soils can be determined readily through knowledge of nominal hydraulic loadings and moisture tension conditions because of easily predictable flow in these soils. Structured soils are far more complex and often short-circuit wastewater through natural macropores of those created by roots and worms. Bouma (1977) presents examples of this short-circuiting to show nominal contact time to actual contact time ratios in some soils of 23:1 or more. Therefore, the simple designation of a vertical separation distance may not ensure against the passage of pathogens to groundwater in certain soils, especially if no control of hydraulic loading is provided. However, a requirement of 0.9 m (3 ft.) or more vertical separation would appear to be a reasonable attempt to improve purification. Thirteen of 41 states required less than 0.9 (3 ft.) of separation in the 1980 survey.

Horizontal separation or setback distances to water supplies, which in most rural locations are wells, also varied widely in the surveys. In 1949 the modal (17 of 32 states) setback distance required between the SAS and the water supply was 15 m (50 ft.), while in 1976 it was 30 m (100 ft.) in 21 of 38 states. In relation to setback requirements for surface waters, both surveys indicate that modal separation was 15 m (50 ft.). The water supply setback requirement increases would appear to reflect a concern for the travel of pathogens through the groundwater to a well supply. In reviewing the waterborne disease outbreaks data for 1970 to 1974, Kreissl (in press) noted that in all outbreaks traced to ST-SAS's, the separation distances were in excess of 30 m (100 ft.). Of course, the travel of pathogens is influenced by several factors in addition to separation distance alone. However, the mere codification of a minimum setback distance in and of itself does not insure against pathogenic contamination of wells, making the reliance on setback distances for health protection a serious misconception on the part of regulators.

2.6 MISCELLANEOUS CODE ISSUES

Since all design loading rates are based on an assumed flow which is generally related to the number of bedrooms times two persons per bedroom, an interesting observation of the 1980 survey is that 19 of 33 states use 284 L/cap.d (75 gal/day/capita) for design, while 12 states use 380 to 510 L/cap.d (100 to 150 gal/day/capita) and 2 states use 190 to 230 L/cap.d (50 to 60 gal/day/capita). These values are of interest when viewed with the knowledge that actual usage averages about 170 L/cap.d (46 gal/day/capita). The allowable maximum percolation rate found in the 1980 survey which permits use of conventional systems is normally 1440 s/cm (60 min./in.) (26 states). However, this maximum varies from 360 to 2,880 s/cm (15 to 120 min./in.) in the other states. The earlier discussion of the invalidity of the percolation test is fortified by this variability.

Several other miscellaneous factors have crept into state codes in recent years. Among them are replacement area requirements, reduced infiltrative areas for alternative pretreatment systems, and provisions for alternative systems. The 1980 survey indicated that 21 of 45 states require an SAS replacement area (generally, 100 percent of the original system area). Such requirements, without any alternating bed provisions, appear to admit both failure of present design criteria and lack of understanding of system functioning.

Another parameter identified as widely variable in 1980 is the maximum allowable slope of the land. Eight of 18 reporting states allow up to 25% slope, while 3 states do not permit systems on slopes of greater than 15 percent and one permitted construction on slopes up to 50 percent. Although 25 percent slope is usually cited as the upper limit for backhoe operation, hand-dug systems have been successful on slopes of up to 50 percent.

Provision for alternative designs has been incorporated into 48 of the 50 states codes according to the 1980 survey. However, the author is aware of alternative systems in both of the states whose codes apparently do not allow them. Therefore, the need to provide alternative systems which can overcome site restrictions which preclude conventional ST-SAS's has been universally perceived.

3 SUMMARY DISCUSSION

Although the U.S. Environmental Protection Agency can fund the construction of onsite wastewater treatment and disposal systems under the Construction Grant provisions of the Clean Water Act, the Agency requires the use of the standards promulgated by the state in which the project is located. Since each state code for conventional onsite systems varies considerably from the others and few have standards for unconventional onsite systems, Federally funded projects incorporate a wide variety of system designs.

State codes for onsite system design have historiclly been very prescriptive and rigid in nature, allowing minimal judgement on the part of field personnel. State codes dealing with onsite wastewater treatment and disposal systems have generally undergone significant change in the three decades chronicled by four nationwide surveys. The changes, however, generally lag technology advances by several years, possibly due to a lack of a significant number of water-borne disease outbreaks clearly traced to code shortcomings. As Plews (1976) pointed out, the time lag or deviation from the technological state of the art can also be due to political pressures. With improved site evaluation capability and the array of alternative technologies now available to provide acceptable sanitation for almost any site, use of flexible guidance criteria in place of restrictive codes is feasible. For example, in the State of Maine, much of the old traditional code was abandoned in 1974 due to an inordinately high failure rate for onsite systems. By implementation of licensed site evaluators who are rigorously trained and monitoried by the State Department

of Human Services to provide comprehensive soil evaluations prior to system identification, design and installation, the malfunction rate has become insignificant (Moreau, 1982). A related consequence of this program has been the use of the qualified feedback from these evaluators to revise important design parameters, such as design loading rates.
Other states, such as Oregon, Minnesota, Wisconsin and North Carolina, have also been undergoing significant changes, including an increased emphasis on qualified site evaluation. The conclusion that one can draw from the above examples, is that there is less lag time between technology advances and code changes, due to increased flexibility, in states where management of onsite wastewater systems has improved through upgrading of staff capability, training programs, and monitoring/feedback/technical assistance programs.

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